Top Mass Measurement in the Di-Lepton Channel at D0

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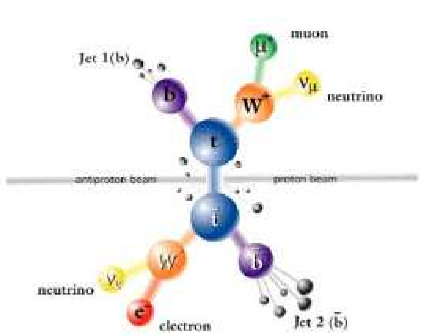
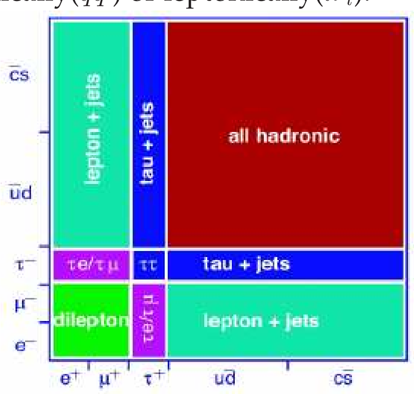
Top Quark Pair Production

Once produced, $t\bar{t}$ pairs immediately decay into 2 b's and 2 W's. The W's then decay either hadronically($q\bar{q}'$) or leptonically($l\nu_l$).



Top Pair Production.



Decay channels in top pair production (with an $e\mu$ final state).

Backgrounds

The dilepton part of the $t\bar{t}$ decay spectrum has smaller backgrounds than the hadronic ones. (A pair of charged leptons cannot be made by QCD alone). However there are several processes which share our final state:

channel	background
$e\mu$	$Z+2jets \rightarrow \tau\tau+2jets$
	$WW+2j \rightarrow ll+2j$
ee	$Z+2j \rightarrow ee+2j$
	$Z+2j \rightarrow \tau\tau+2j$
	$WW+2j \rightarrow ll+2j$
$\mu\mu$	$Z+2j \rightarrow \mu\mu+2j$
	$Z+2j \rightarrow \tau\tau+2j$
	$WW+2j \rightarrow ll+2j$

Data Selection

After demanding two good, isolated leptons (depending on channel), two good jets, and either large missing transverse energy (ee,$\mu\mu$), or large total transverse energy ($e\mu$), we get the following yeilds:

source	$t\bar{t}(7pb)$	WW,Z	fake ℓ	total	obs.
untagged	15.7 ± 1.3	3.8 ± 0.6	0.31 ± 0.15	19.9 ± 1.5	21
b-tagged	10.0 ± 0.8	0.13 ± 0.03	0.08 ± 0.11	10.2 ± 0.9	14

Expected vs. observed event yield.

Kinematic Solutions, Weights

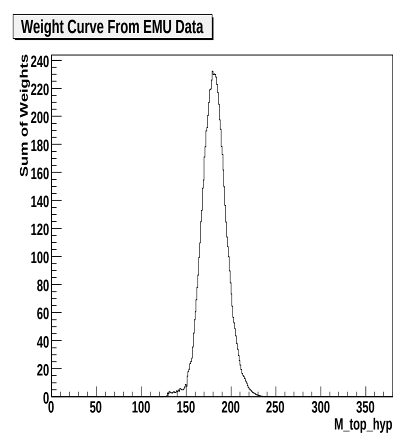
The only information we have about the momenta of the two neutrinos comes from the missing energy: $(\vec{p_{\nu1}}+\vec{p_{\nu2}})_T = \not{E}_T$

Even if we knew the other 4 momenta in the problem perfectly, we would still be unable to extract the top mass directly. As it turns out, if we hypothesize a value for the top mass, we can find all the possible top momenta (always ≤ 4).

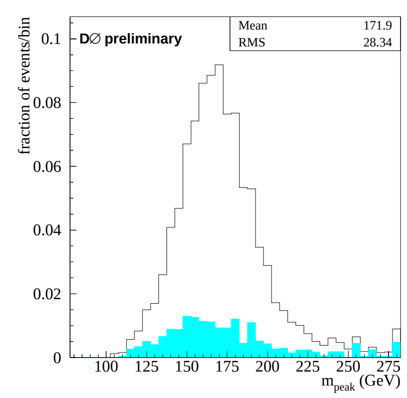
We then apply a weight to each solution given by:

$$w = f(x)f(\overline{x})p(l_\mu\bar{t}^\mu)p(\bar{l}_\mu t^\mu)$$

Where l and t are the 4-momenta of the lepton and top. After varying (or smearing) the known momenta to account for finite detector resolution, and adding the weight values at a given hypothesized mass, we end up with a distribution of weights vs. m_{t_hyp}



Weight Curve from an $e\mu$ data event.



Distribution of peak masses in Monte Carlo (total, and background only).

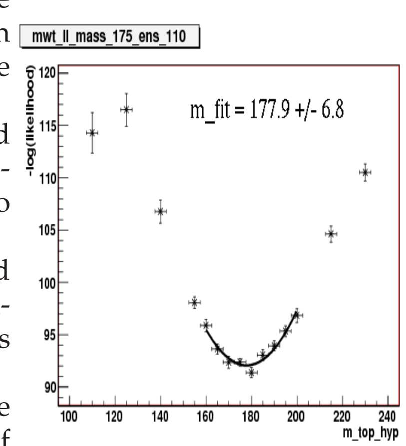
Template Based Likelihood Fit

Templates are formed from the distribution of peak masses in the signal and background Monte Carlo (shown above).

The distributions are then scaled to match the expected contributions from each, and put into $10GeV$ bins.

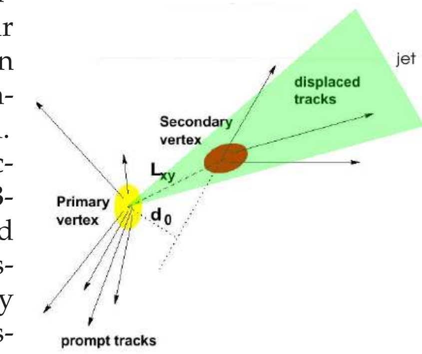
Events are given a likelihood based on the value of the distribution in the bin that its peak mass falls into.

At right: An example negative Log-Likelihood curve for a set of 40 Monte Carlo Events.



B-tagging

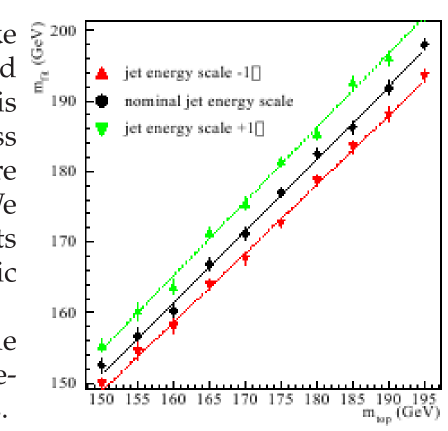
Essentially all $t\bar{t}$ events contain b-quarks, and most of our backgrounds don't, so we can lower our backgrounds substantially with a b-tagging algorithm. One such algorithm the Secondary Vertex Tagger (SVT). B-hadrons have long lifetimes, and their decay verticies occur are displaced enough from the primary vertex for the $D\emptyset$ tracker to distinguish them.



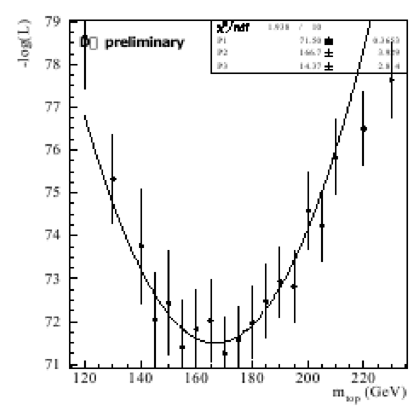
Ensemble Testing

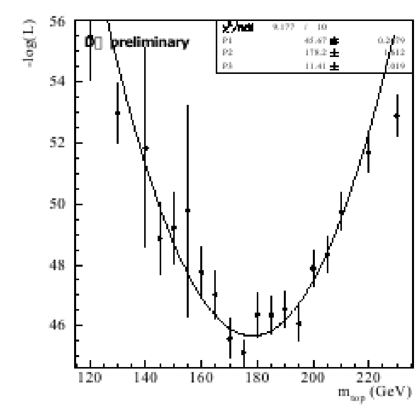
Before we can confidently make a measurement on data, we need to ensure that, our technique is consistent at extracting the mass from Monte Carlo events where we already know the mass. We also use these calibration plots when estimating our systematic error.

At right: Effect of Jet Energy Scale uncertainty on the calibration between fitted mass and true mass.



Combined Result





Left: Untagged data $(167\pm14(stat)\pm4(syst)GeV)$
Right: Tagged date $(175\pm12(stat)\pm4(syst)GeV)$